



Yield variability in organic versus conventional systems : a meta-analysis for horticultural systems

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ESA 2018, August 27-31, 2018, Geneva, Switzerland

Introduction



- All over the world, organic agriculture is becoming of growing importance in the agricultural sector
 - 50.9 millions ha certified OA (2015) compared to 11 millions ha in 2011
 - 2,4 millions farmers
 - 1.1% of global agricultural land (6% of agricultural land in Europe)
- Organic agriculture is associated with lower impacts on natural resources and benefits on human health at local and global scales

FIBL & IFOAM, 2015. Frick and Bonn, The world of organic agriculture 2015

Willer & Lernoud, 2016, 2017.

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Concerns with the capacity of organic agriculture to produce enough food and meet the demand of a growing population.

Lower yields ?

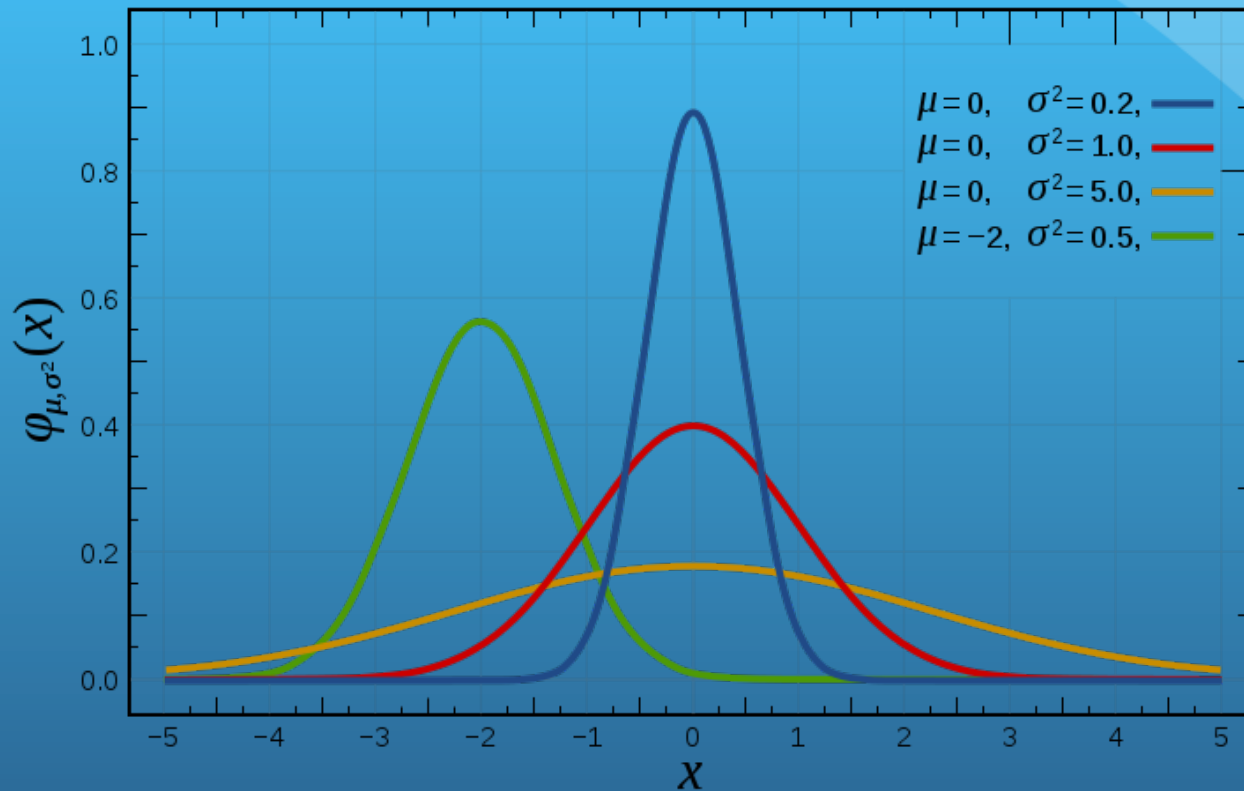
Can Organic Agriculture feed the world ?



Badgley et al., 2007, De Ponti et al., 2012, Seufert et al., 2012, Ponisio et al., 2014. :

- - 8 to - 25 % depending on crop species, growing conditions and management practices
- Some controversies

YIELD and VARIABILITY



Are organic yields lower than conventional ones ?
Are they more or less stable ?

What about organic yield variability ?

- Two contrary hypotheses:
 - OA can be assumed to be more vulnerable to pests and diseases outbreaks leading to high yield variability
 - OA is based on a greater structural biodiversity and optimization of nutrient cycling and biological pest regulation which may induce a higher resilience of the system and yields

The case of horticulture

- Horticulture is defined here as production of fruits & vegetables in fields, market gardens and orchards
- Pesticides are a risk for consumers and producers
- Yield variability means economic risk for producers. Horticultural producers are particularly risk adverse due to high production costs and possible large losses



Material & Methods

A meta-analysis on published scientific literature worldwide

Literature search and Database composition

- A Systematic review was performed with a specific equation and criteria (yield data, primary data from experimental stations or on-farm trials)
- 52 papers
- 560 yield ratio
- 50 sites (ES)
- 37 horticultural species
- 6 crop types : fruit tree, small fruit, other fruit (e.g. melon, banana), spice, tuber root, vegetable
- 4 product types : bulb, leafy, fruit, root
- 17 countries standing for various climatic zones

Material & Methods

- Mean yield ratio estimation

We calculate the natural log of the response ratio. The ratio allows to compare yield data from different units and species

- $Y = \ln (X_o/X_c)$

- X_o is the average organic yield
- X_c is the average conventional yield

- 8 statistical models with mixed or fixed effects

Material & Methods

Influence of covariables

The effects of 7 covariables were studied :

- type of crop (fruit tree, small fruit, other fruit, spice, tuber roots, vegetable),
- type of product (bulb, fruit, leafy, root),
- annual vs perennial,
- legume vs non legume,
- climate (mediterranean, subtropical, temperate, tropical),
- OH system type (biodynamic, certified, organic standards, transition),
- CH system type (high input, low input).

The 8 models were compared for each covariable. The effects of each covariable modality was studied based on the p-values.

Variability : Comparison of Organic yield and conventional yield variances accross replicates and accross years

Intersite variability

Yield ratio distributions across experiments were computed for each model.

Intrasite variability

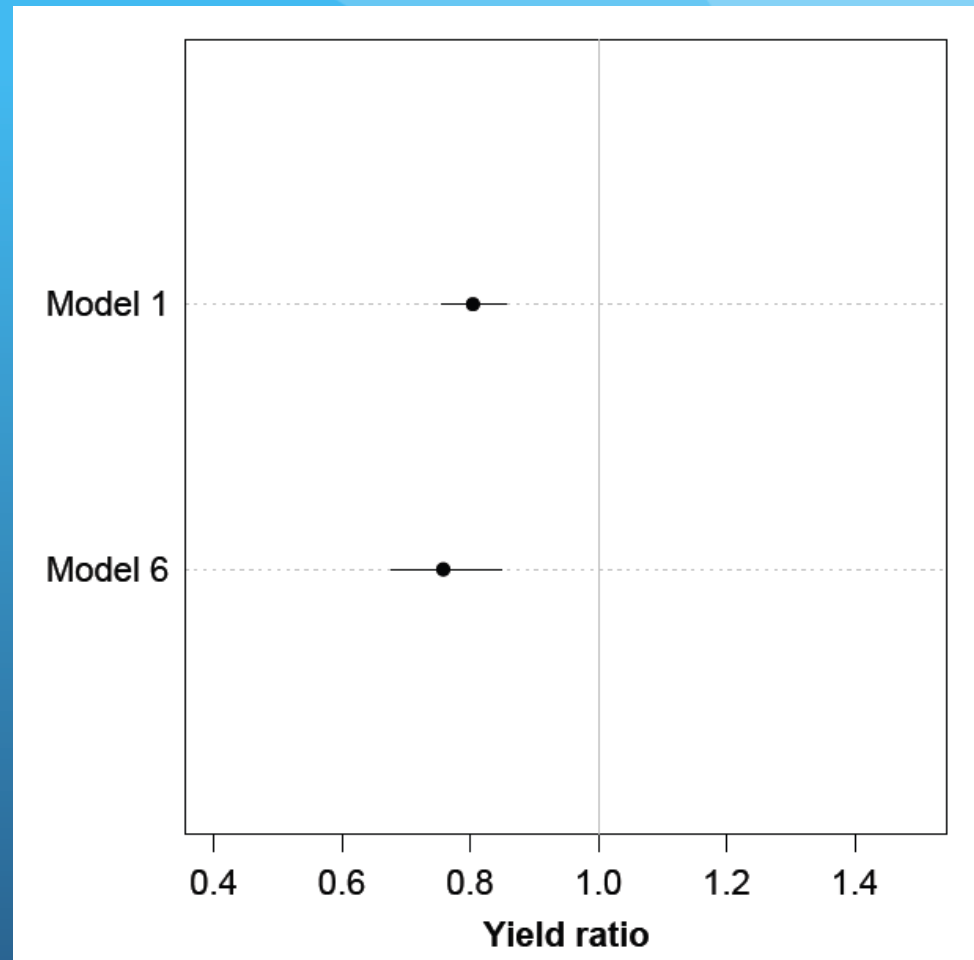
Intrasite variability was studied on the selection of EU where sd were informed : a variance ratio was estimated

Interannual variability

Experimental units (EU) with at least 5 years of data were selected. For each selected EU, interannual yield variances were computed and compared. Mean interannual variance ratio was estimated using a mixed model with ES as random effect.

RESULTS

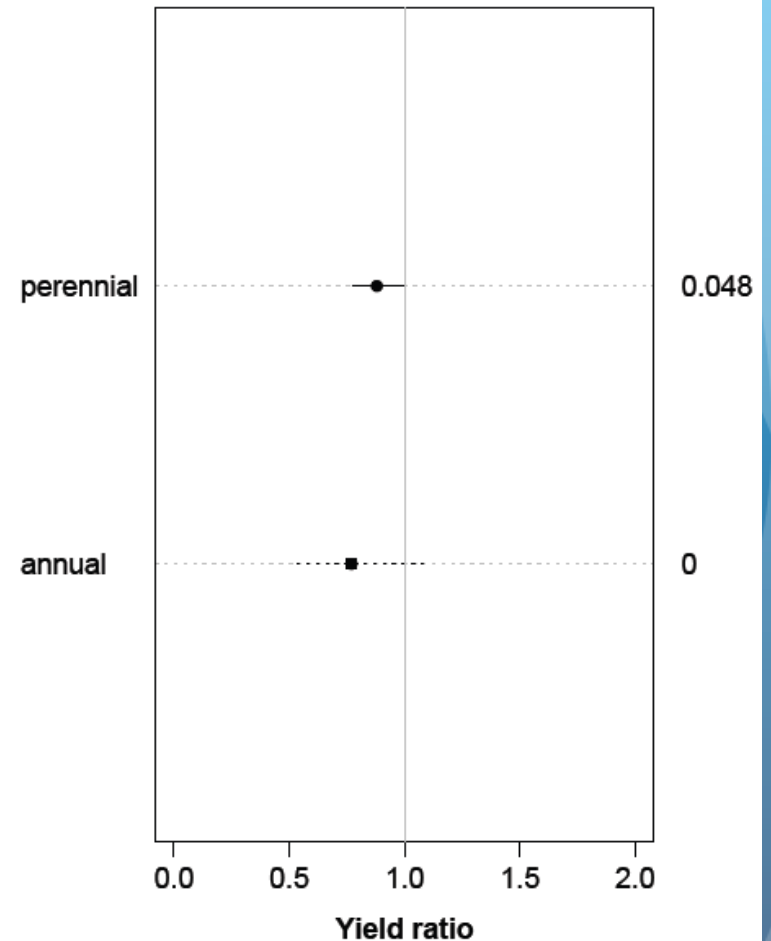
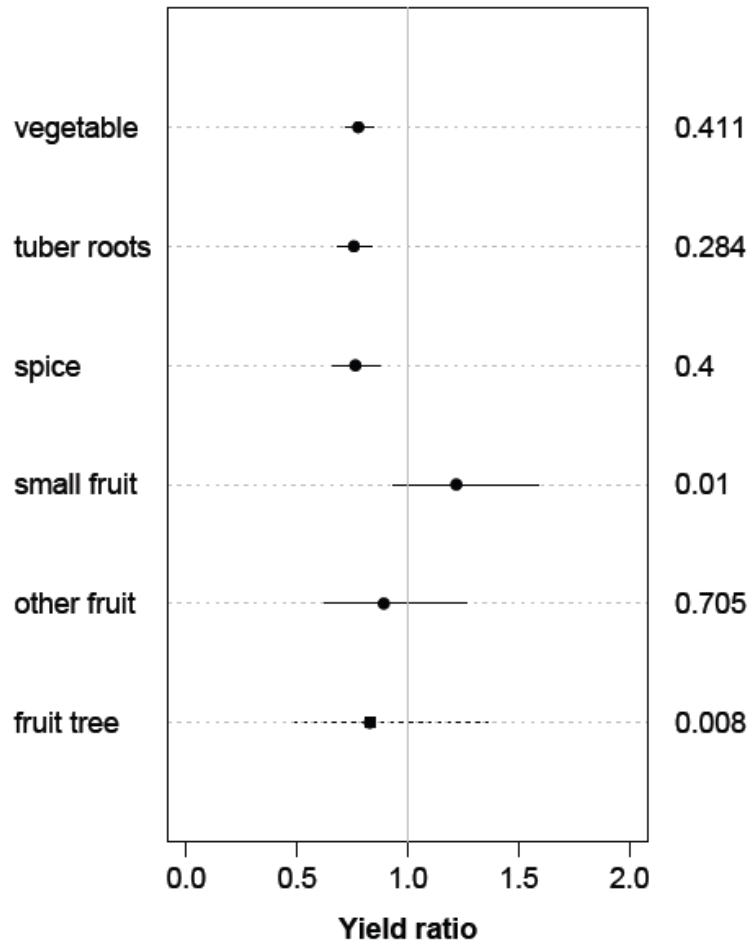
- The average ratio of organic to conventional yield is equal to 0.83.
- OH yields are in average 10 to 32 % lower than CH yields
- A result consistent with last meta-analyses

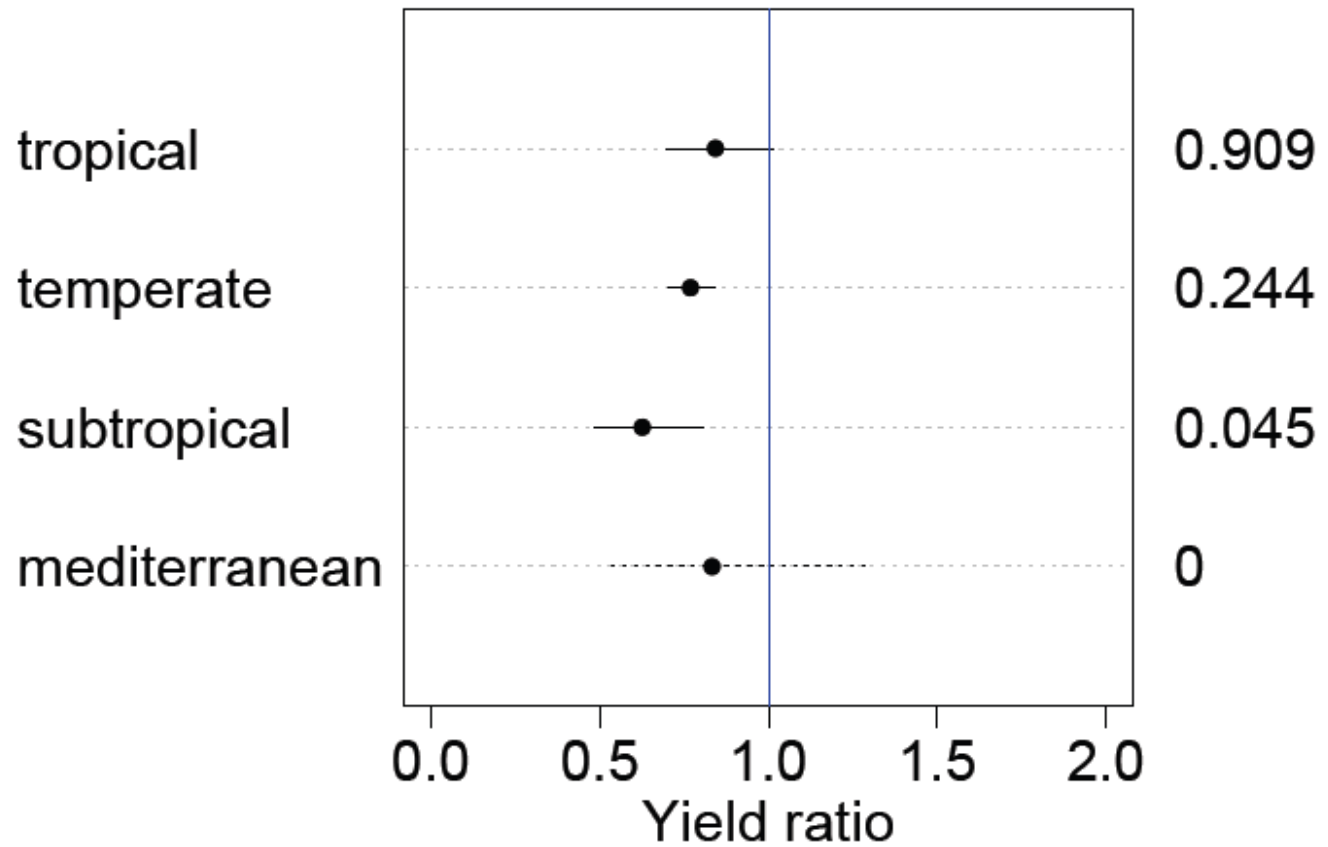


RESULTS

- Yield ratios do not differ accross crop, crop types, product types, biological types.
- Yield ratios do not differ accross organic horticulture types (certified, etc.) or conventional horticultural types (High/low input)
- Yield ratios do not differ accross climates

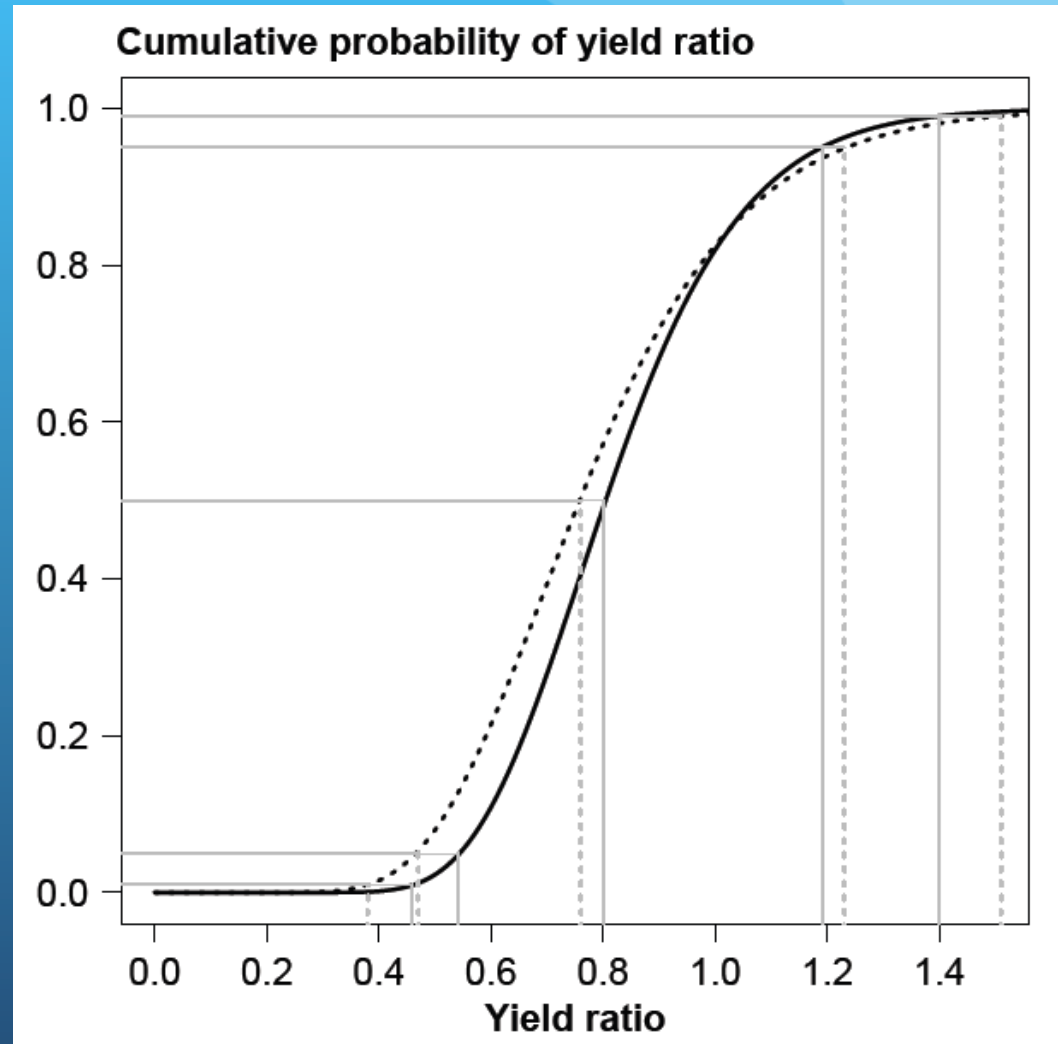
Effects of covariables. Effect of crop type on organic vs. conventional yield ratios. On the right side of each graph stand the p-values. Bars show 95% confidence intervals.





Are organic yields more variable than conventional ones ?

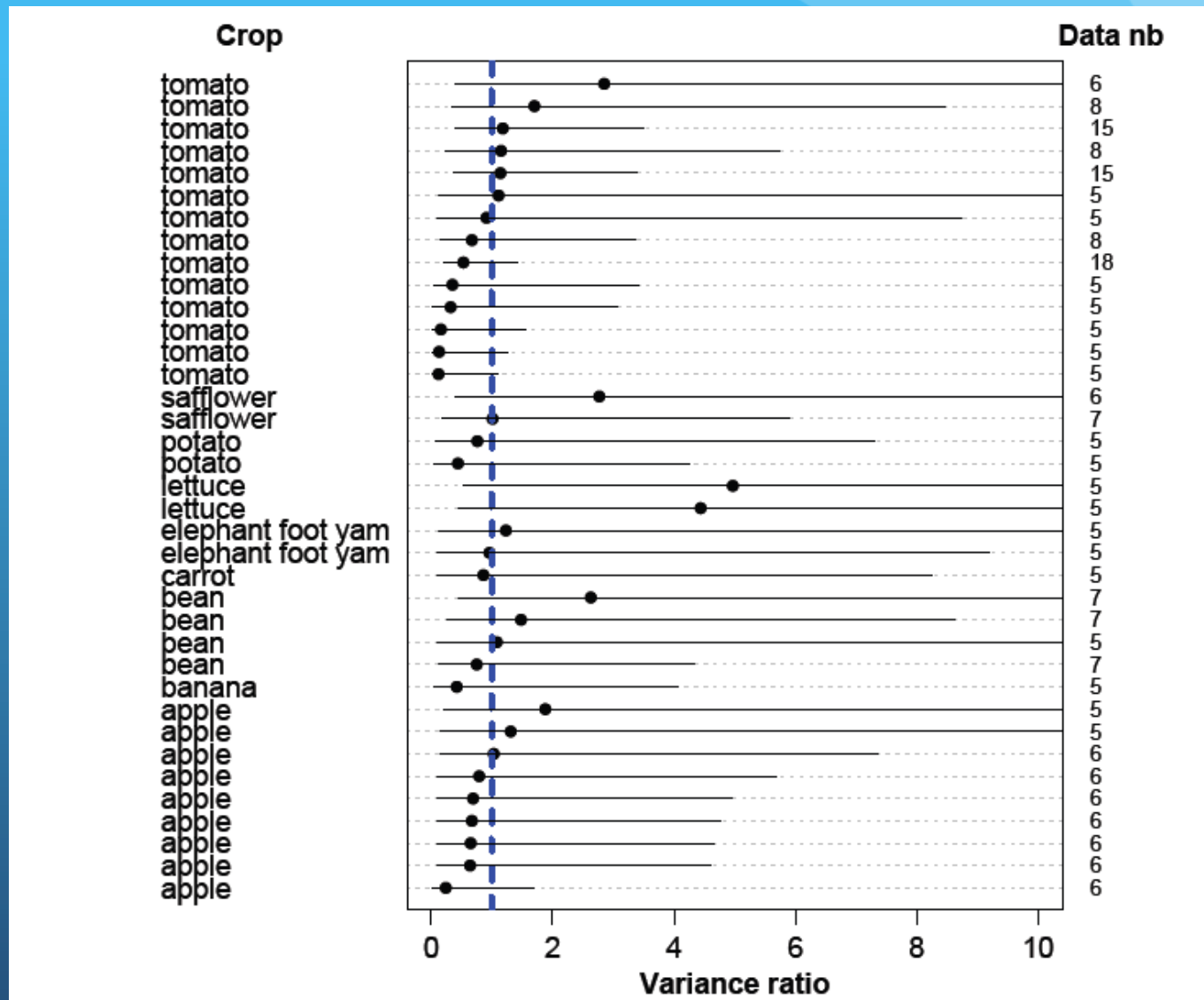
- The cumulative probability of yield ratio shows a high variability
- 90% chance to get a yield ratio higher than 0.5
Yield loss has a 10% chance to exceed 50%
- 20 % chance to get higher yields in Organic vs. conv.



Yield variability accross years

- Interannual variability is analysed based on variance ratio estimated for 36 experimebtal comparisons including at least 5 years of data
- Interrannual variability of organic yields is not significantly higher than conventional one

Ratio of Interannual yield variances (org vs.conv.) estimated for experimental units including at least 5 years of yield data .



The limits of the study

- Most data on tomato (32%), apple (10%), potato (9%)
- 2/3 of experiments in 4 countries (USA (41%), Italy (8%), Switzerland (8%) and Germany (8%))
- Few data in Asia, central America and Africa
- In our study, the relative effects of input use , diversification, rotation or mangement practices (tillage, fertilisation, pest management) were hard to disentangle
- We could not identify the causes of variability

Conclusion

- OH yields are in average 10-32 % less than CH yields
- But the probability to get high losses is low
- Yield distributions are important to consider for farms sustainability : we show that yield instability was not significantly different in conventional vs. organic horticulture
- Studies remain scarce especially in developing countries
- In paralel to productivity, it is of course important to consider environmental and social benefits of organic production

Thank you for your attention

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Lower average yields but similar yield variability in organic versus conventional horticulture. A meta-analysis

Agron. Sustain. Dev, 2017, 37-45

